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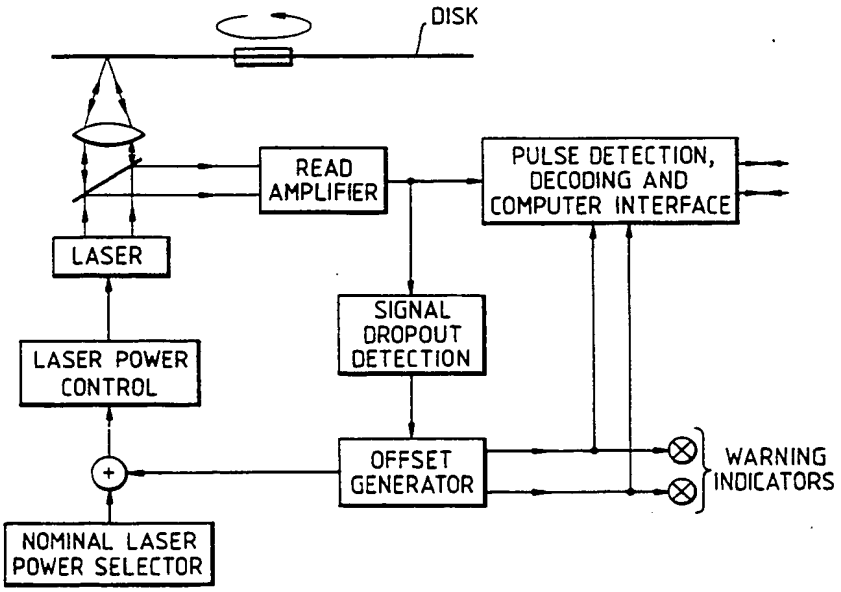
(54) Title: IMPROVING OPTICAL DISK RECORDING PERFORMANCE



REDUCING THE EFFECT OF OPTICAL PATH ATTENUATION ON WRITE PERFORMANCE

(57) Abstract

A method and apparatus for improving optical disk recording performance is disclosed, which comprises reading data from an optical disk while writing data to the disk in order to verify the data, to control the power of the recording laser and to prevent overwriting of the disk.

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IMPROVING OPTICAL DISK RECORDING PERFORMANCE

This invention relates to the improvement of optical disk recording performance.

During the recording process of writable optical disks, data is written as the disk rotates. To check that the data was written correctly, it is read back from the disk (usually known as verifying the data) on the following revolution. It therefore takes two revolutions of the disk to successfully write and verify data.

We have found that the time to write and verify data can be halved by reading the data from the disk while writing it (Direct Read During Write, DRDW).

Write Once optical disks (WORM disks) made by Plasmon Data Systems use a 'moth eye' texture as the recording medium (see, for example, U.S. Patents 4,616,237; 4,786,585; 4,724,444; and 4,758,307). Marks written by the laser form very quickly (typically 5-20ns). Mark formation can be detected by monitoring the read photodiode during writing (see Figure 1).

Accordingly, one aspect of the present invention provides a method for improving optical disk recording performance which comprises reading data from an optical disk while writing data to said disk.

If every bit of data is written successfully there will be no errors when reading the data. Indeed, the read channel error correction can cope with several bits in error before reporting a verify failure.

In one embodiment of this invention, there is provided a pulse detector capable of detecting marks forming on the disk surface during write. If the normal mark formation is not seen, it is a bad mark, or bit in error. By simply counting the number of bad marks during writing, data which will pass the verify read can be positively identified by observing a low count (of the order of a few bits) on the bad pulse counter.

In cases of few bits in error being detected, no

verification is required.

If more than a few bad marks are detected, the normal verify sequence is triggered. This will test whether the error correction can cope with the number of bits in error.

Figure 2 shows the distribution of numbers of bits in error in sectors on a typical Plasmon disk. Most sectors have no bits in error, and so a high hit rate of zero counts can be expected (approximately 99.3%). If two bits in error are taken as acceptable, the hit rate would be 99.8%. The time to perform most writes should therefore be halved.

Recording marks on optical disks requires accurate control of laser power. A small percentage change in the write power will cause a dramatic difference in the written mark size.

Accordingly, in a second embodiment of the present invention, there is provided laser power control using feedback photodiodes within the laser module to provide the desired laser power. Outside of the laser module, optical elements direct the light to and from the disk surface.

In normal operation the optical elements get dirty with airborne dust, smoke particles etc. Each dirty surface reduces the laser power by a (small) percentage. The optical disk surface can also get dirty causing further signal loss.

There is a greater latitude in laser power during reading due to careful circuit design, while accurate write laser power is demanded by the physical properties of the disk. Writing data will become unreliable long before reading is impaired.

In practice, Plasmon have found the problem may cause poor disk drive performance (many write-retry attempts), with possible loss of data.

By monitoring the mark formation during writing (see Method 1 of improving drive performance), poorly formed, and low amplitude marks can be detected. It is possible to use the written mark amplitude to adjust the laser power up or down as necessary. By careful use of time constants in the control circuit, disk defects should not cause sudden glitches in the write power (see Figure 3).

When the drive control attempts to increase the laser power more than a given percentage, the user can be warned that the optical elements, or disk are in need of cleaning.

A second level of warning can be set when the maximum laser power has been reached, informing the user that the write performance has been impaired due to an obscured optical path.

Write once optical disks (WORMs) cannot be erased. However, if data is written in a given sector, and the drive is requested to write the same sector again, the original data is corrupted, and lost forever. In normal operation, host computer software will prevent the overwriting of existing data.

However, in cases of software bugs, or other errors, an erroneous write could prove disastrous.

Checking that a sector is blank by reading it before writing it is unacceptably slow involving an extra disk revolution before each write operation.

According to a third embodiment of the present invention, marks are monitored as they are being formed on the disk surface. Mark formation is very rapid on the 'moth eye' surface (typically 5-20ns). Figure 4 shows marks being formed on Plasmon media. If the area of the disk is already written, the mark formation signal looks different (see Figure 5).

By analysing the mark formation signal, and the differential of the mark formation signal, it is possible to distinguish between normal and overwrite conditions.

Using this method, it is only possible to detect when writing over an already written pulse. The read channel must therefore be observed between each write pulse for the presence of already written bits. By using a carefully chosen start up signal, it is possible to detect overwriting in all situations (see Figure 6), before any user data is written.

It is therefore possible to prevent overwriting in hardware at the lowest possible level.

CLAIMS

1. A method of improving optical disk recording performance which comprises reading data from an optical disk while writing data to said disk.

2. A method according to claim 1, wherein data written to said disk is read and verified immediately after being written, and wherein said data is in the form of marks formed in the disk by a laser beam.

3. A method according to claim 2, wherein said data is read by monitoring the formation of said marks with a read photodiode during writing.

4. A method according to claim 3, wherein said read photodiode is connected to a pulse detector, which pulse detector is capable of detecting said marks forming in said disk during writing.

5. A method according to claim 4, wherein said pulse detector is arranged so as to count the number of abnormal marks formed.

6. A method according to claim 5, wherein a verifying sequence is triggered if more than a pre-determined number of abnormally formed marks are detected.

7. A method according to claim 4, wherein said pulse detector is arranged so as to measure the amplitude of said marks formed.

8. A method according to claim 7, wherein the power of the writing laser is controlled as a function of the amplitude of said marks.

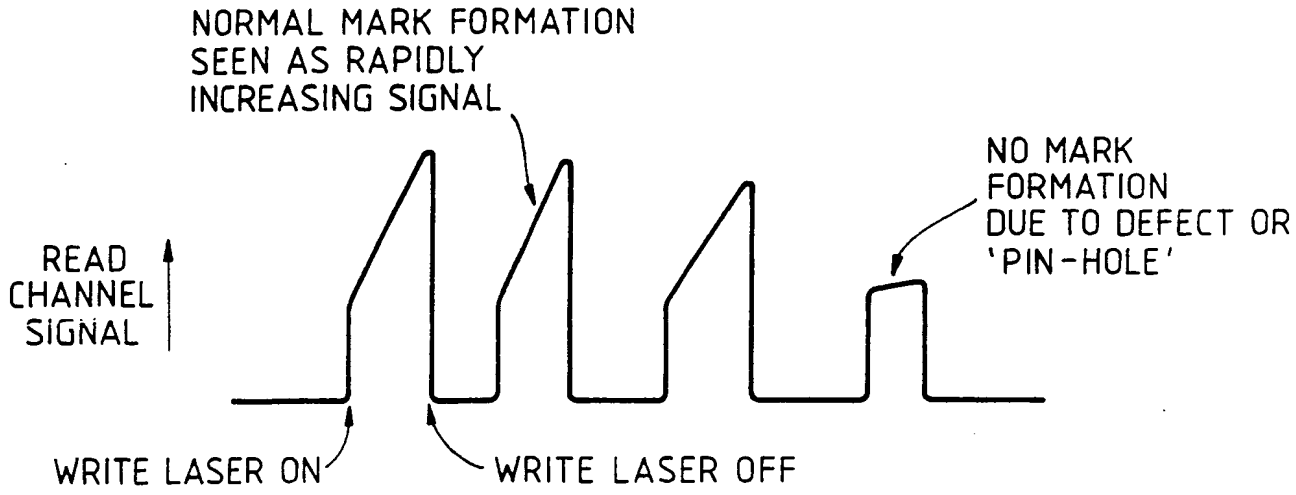
9. A method according to claim 8, wherein an indication is given when the power of said laser is higher than, or at, a pre-determined level.

10. A method according to claim 4, wherein said pulse detector is arranged so as to detect whether the area of said disk being written to has already been written to.

11. A method according to claim 10, wherein said pulse detector is arranged so as to detect whether the area about to be written to has already been written to.

12. A method according to claims 10 or 11, wherein overwriting of the disk is minimised.

Fig. 1.



MARK FORMATION ON PLASMON MEDIA

Fig. 2.

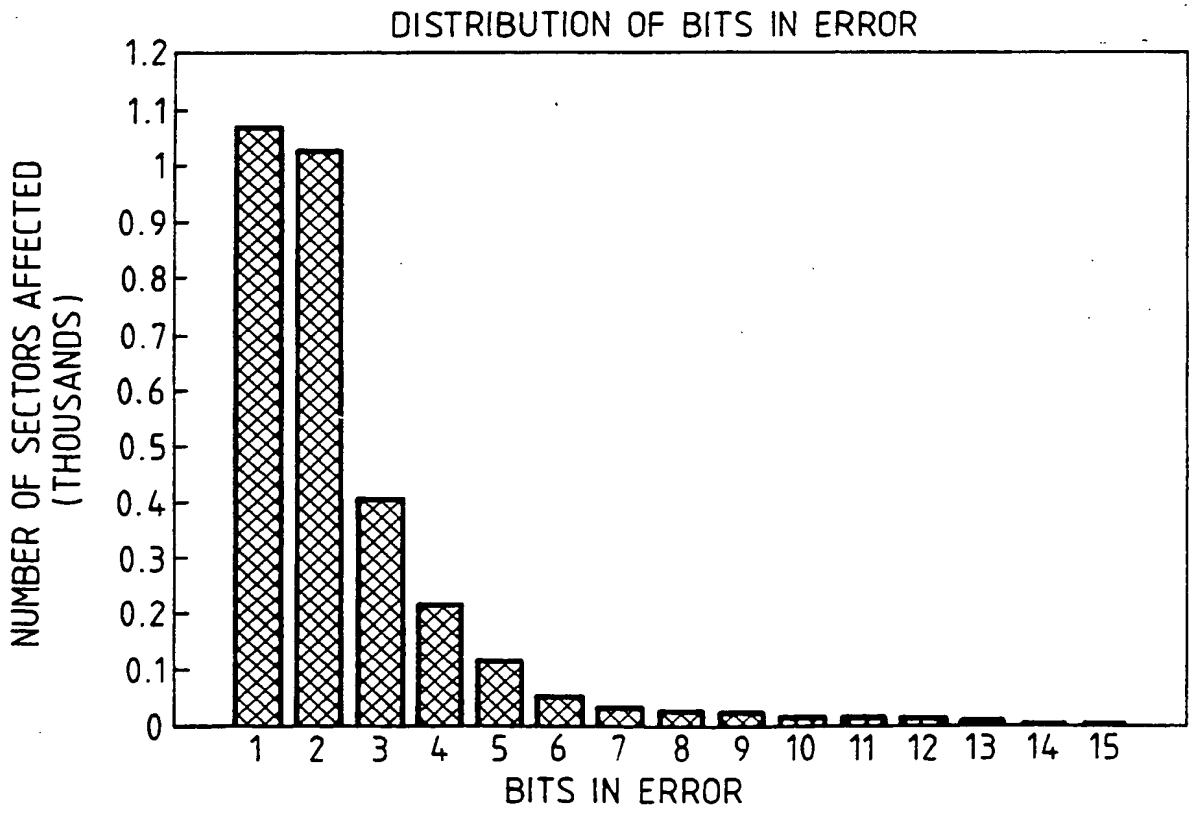


Fig. 3.

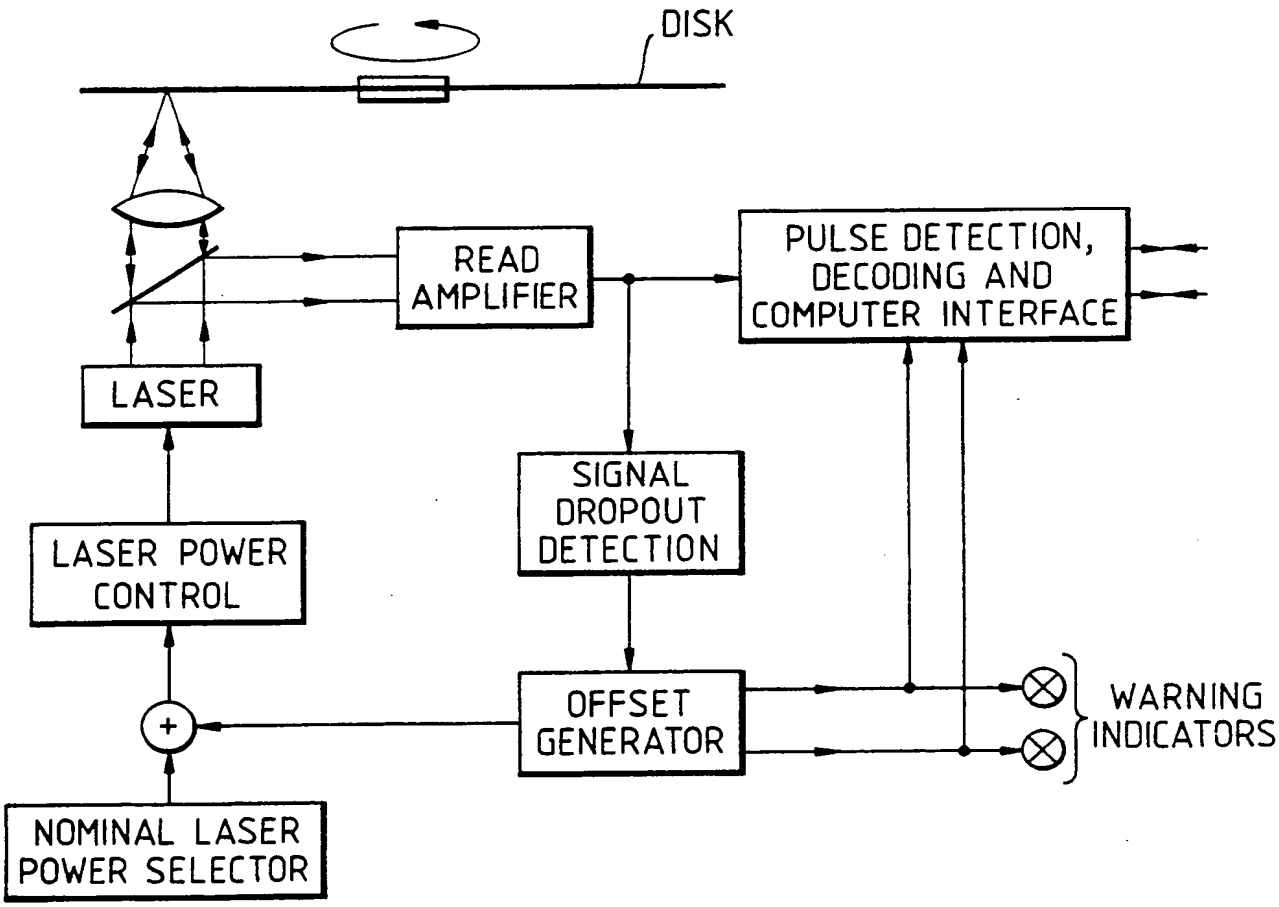


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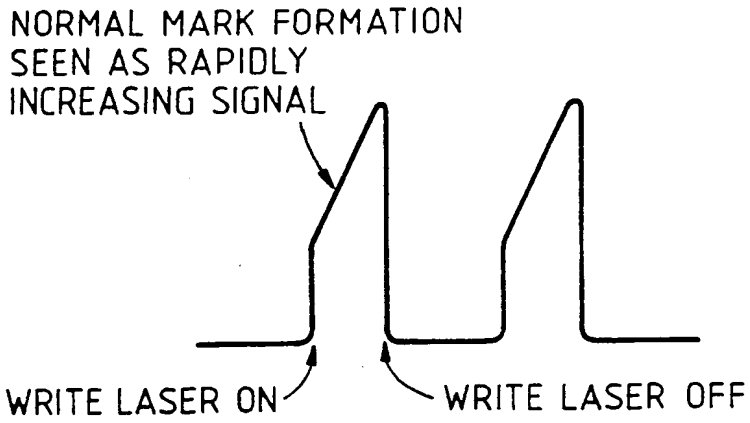
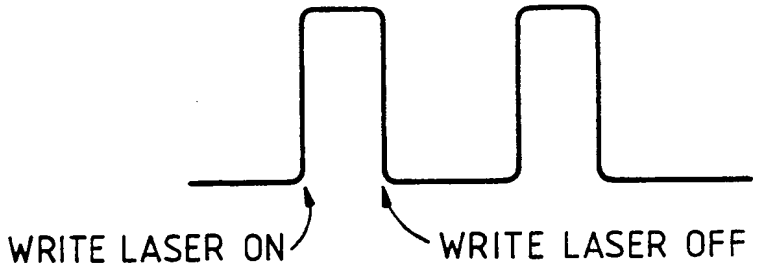
Fig. 4.



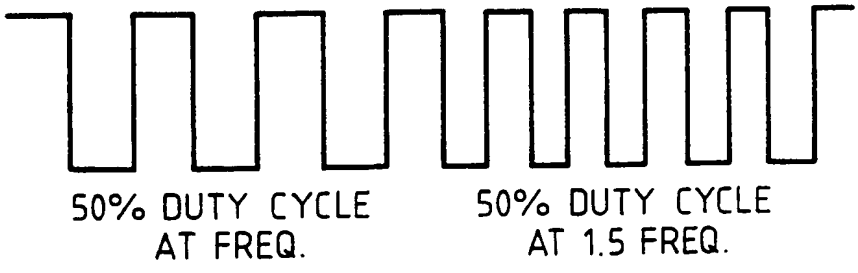
NORMAL MARK FORMATION ON PLASMON MEDIA

Fig. 5.



OVERWRITE OCCURRING ON PLASMON MEDIA

Fig. 6.



START UP SIGNAL TO DETECT OVERWRITING

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/02186

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 11 B 7/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 11 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US, A, 4680594 (R. R. BRACHT) 14 July 1987, see the whole document	1-6
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X	US, A, 4648085 (S. SHIMONOU) 3 March 1987, see column 7, line 3 - column 9, line 5	1-3
Y		4,7
	--	
X	EP, A2, 0182127 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 28 May 1986, see page 2, line 35 - page 3, line 24; claims 1,2	1,2
Y		3,4,7, 10
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* Special categories of cited documents:[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
27th February 1992	11. 03. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Nicole De Bie

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4606016 (J. J. VERBOOM ET AL) 12 August 1986, see column 4, line 23 - column 5, line 36	1-4,7, 10
P,X	EP, A2, 0420252 (KABUSHIKI KAISHA TOSHIBA) 3 April 1991, see column 9, line 42 - column 11, line 4; column 13, line 42 - column 17, line 6	1-4,10-12
P,A		5-9

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/GB 91/02186

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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US-A- 4648085	03/03/87	JP-A-	59207435	24/11/84
		JP-A-	59207436	24/11/84
EP-A2- 0182127	28/05/86	JP-A-	61126643	14/06/86
		US-A-	4631706	23/12/86
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